इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 16098-1 (2013): Structured-Wall Plastics Piping Systems for Non-Pressure Drainage and Sewarage - Specification, Part 1: Pipes and Fittings with Smooth External Surface, Type A [CED 50: Plastic Piping System]

“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

भारतीय मानक

ग़ैर-दबाव जल निकासी और सीवरेज के लिए संरचित–दीवार प्लास्टिक पाइपिंग पद्धतियाँ — विशिष्टि

भाग 1 चिकनी बाहरी सतह के साथ पाइप और फिटिंगें, टाइप ए

Indian Standard

STRUCTURED-WALL PLASTICS PIPING SYSTEMS FOR NON-PRESSURE DRAINAGE AND SEWERAGE — SPECIFICATION

PART 1 PIPES AND FITTINGS WITH SMOOTH EXTERNAL SURFACE, TYPE A

ICS 23.040.20; 23.040.45; 91.140.80; 93.030

© BIS 2013

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

March 2013 **Price Group 10**

Plastic Piping Systems Sectional Committee, CED 50

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Plastic Piping Systems Sectional Committee had been approved by the Civil Engineering Division Council.

This standard on structured wall plastic piping systems for non-pressure underground drainage and sewerage has been published in two parts. The other part in the series is:

Part 2 Pipes and fittings with non-smooth external surface, Type B

In the formulation of this standard considerable assistance has been derived from ISO 21138-1 and 2 : 2007 'Plastic piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) — Part 1: Material specifications and performance criteria for pipes, fittings and system and Part 2: Pipes and fittings with smooth external surface, Type A'. However, only PVC-U structured wall pipes with foam core/hole core constructions have been included as other type of pipes are not being manufactured in India at present. The test for low temperature installation performance — Impact resistance (staircase method) at –10° C has not been included due to the Indian climatic conditions. The dimensions for solvent cement jointing system have been provided as the same practices are widely followed in India. Sizes being widely used in India have also been included.

Piping systems conforming to this standard are resistant to corrosion by water with wide range of *p*H values such as domestic waste water, surface water and ground water. If piping system conforming to this standard is to be used for chemically contaminated waste waters such as industrial discharges, chemical and temperature resistance must be taken into account. Guidance on the chemical resistance of PVC-U and PE materials is given in IS/ISO 10358 'Plastics pipes and fittings — Combined chemical-resistance classification table' (*under preparation*).

Guidelines on structural design of thermoplastics pipelines have been provided in Part 2 of this standard for information.

Information on creep in thermoplastic material has been given in Annex A.

General guidance regarding laying and jointing of PVC-U pipes has been provided in IS 7634 (Part 3) : 2003 'Code of practice for plastic pipe work for potable water supplies: Part 3 Laying and jointing of PVC pipes'. However, some additional requirements for these pipes have been given at Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STRUCTURED-WALL PLASTICS PIPING SYSTEMS FOR NON-PRESSURE DRAINAGE AND SEWERAGE — SPECIFICATION

PART 1 PIPES AND FITTINGS WITH SMOOTH EXTERNAL SURFACE, TYPE A

1 SCOPE

This standard (Part 1) specifies requirements for pipes and fittings with smooth external surface Type A, based on PVC-U structured wall piping system in the field of non-pressure systems for underground drainage and sewerage.

It is applicable to PVC-U structural wall pipes and fittings with or without an integral socket with elastomeric sealing ring joints or solvent cement welding joints. This standard covers the range of pipes and fittings sizes from 110 mm to 1 200 mm nominal outside diameter.

NOTES

1 These pipes, fittings and system can be used for highway drainage and surface water.

2 Other thermoplastic materials can be added *via* an addendum.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
4905 : 1968	Methods for random sampling
5382 : 1985	Specification for rubber sealing rings for gas mains, water mains and sewers (*first revision*)
12235	Thermoplastics pipes and fittings — Methods of test (*first revision*)
(Part 1) : 2004	Measurement of dimensions
(Part 2) : 2004	Determination of Vicat softening temperature
(Part 5) : 2004	Longitudinal reversion
(Part 6) : 2004	Stress relief test
(Part 8)	Resistance to internal hydrostatic pressure
(Sec 2) : 2004	Leak-tightness of elastomeric sealing ring type socket joints under positive internal pressure and with angular defection
(Sec 3) : 2004	Leak-tightness of elastomeric sealing ring type socket joints under negative internal pressure and with angular defection
(Part 9) : 2004	Resistance to external blows (impact resistance) at 0°C (round-the-clock method)
(Part 11) : 2004	Resistance to dichloromethane at specified temperature
14182 : 1994	Solvent cement for use with unplasticized polyvinyl plastic pipe and fittings — Specification
15778 : 2007	Chlorinated polyvinyl chloride (CPVC) pipes for potable hot and cold water distribution supplies — Specification
16098 (Part 2) : 2013	Structured-wall plastics piping systems for non-pressure drainage and sewerage — Specification: Part 2 Pipes and fittings with non-smooth external surface, Type B

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Nominal Size (DN) — The numerical designation for the size of a pipe, other than a pipe designated by thread size, which is a convenient round number approximately equal to the manufacturing dimension, in millimetre.

3.2 Nominal Outside Diameter (d_n) — The specified outside diameter assigned to the nominal size, in millimetre.

3.3 Outside Diameter at Any Point (d_e) — The value of the measurement of the outside diameter of a pipe through its cross-section at any point of the pipe, rounded off to the next higher 0.1mm.

3.4 Mean Outside Diameter (d_{em}) — The quotient of the outer circumference of a pipe and 3.142(π) in any cross-section, rounded off to the next higher 0.1mm.

3.5 Minimum Mean Outside Diameter ($d_{em, Min}$) — The minimum value of the mean outside diameter as specified for a given nominal size.

3.6 Maximum Mean Outside Diameter ($d_{em, Max}$) — The maximum value of the mean outside diameter as specified for a given nominal size.

3.7 Inside Diameter of a Socket (d_s) — The value of the measurement of the inside diameter of the socket at any point in any cross-section of the socket.

3.8 Mean Inside Diameter of a Socket (d_{sm}) — The arithmetical mean of four measurements, taken at 45° to each other, of the inside diameter of the socket in the same cross-section of the socket.

3.9 Out-of-Roundness (Ovality) — The difference between the measured maximum and the measured minimum outside diameter in the same cross-section of the pipe.

3.10 Nominal Wall Thickness (e_a) — A numerical designation of the wall thickness of a component which is a convenient round number, approximately equal to the manufacturing dimension in millimetere.

3.11 Wall Thickness at Any Point (e) — The value of the measurement of wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1mm.

3.12 Minimum Wall Thickness at Any Point (e_{Min}) — The minimum value for the wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1mm.

3.13 Maximum Wall Thickness at Any Point (e_{Max}) — The maximum value for the wall thickness at any point round the circumference of a pipe, rounded off to the next higher 0.1mm.

3.14 Mean Wall Thickness (e_m) — The arithmetic mean of at least four measurements regularly spaced around the circumference and in the same cross-section of a pipe, including the measured minimum and measured maximum values of the wall thickness in that cross-section, rounded off to the next higher 0.1mm.

3.15 Maximum Mean Wall Thickness ($e_{m, Max}$) — The maximum value for the mean wall thickness around the circumference of a component, as specified.

3.16 Construction Height (e_c) — Radial distance between the top of ribs or corrugation or in the case of Type A and Type B pipes and fittings, between the outside surface of wall and inside surface of wall.

3.17 Minimum Length of a Spigot ($l_{1, Min}$) — Minimum permitted value for the length of a spigot of a pipe or fitting.

3.18 Tolerance — The permitted variation of the specified value of a quantity, expressed as the difference between the permitted maximum and the permitted minimum value.

3.19 Standard Dimension Ratio (SDR) — A numerical designation of a pipe series, which is a convenient round number approximately equal to the ratio of the minimum mean outside diameter, $d_{em, Min}$ and the minimum wall thickness at any point, e_{Min}

$$\text{SDR} = \frac{d_{em,\text{Min}}}{e_{\text{Min}}}$$

3.20 Nominal Ring Stiffness (SN) — A numerical designation, which is a convenient round number, of the ring stiffness, in kN/m^2, indicating the minimum required ring stiffness of a pipe or fitting.

3.21 Socket-Ended Pipe — An unplasticized PVC pipes whose one end is expanded after heating for the purpose of jointing by solvent cement or jointing using an elastomeric sealing ring, to the plain ends.

3.22 Structured Wall Pipes — A pipe which have an optimized design with regard to material usage to achieve the physical, mechanical and performance requirements of this standard.

3.23 Ring Flexibility — An ability of a pipe to resist diametric deflection without loss of structural integrity.

3.24 Virgin Material — A material in such form as granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessable or recyclable materials have been added.

3.25 Own Rework Material — A material prepared from rejected, unused pipes or the fittings, including trimmings from the production of pipes or fittings that will be reprocessed in a manufacturer's plant by a process such as extrusion or injection moulding and for which the complete formulation is known.

3.26 Tests

3.26.1 *Type Tests*

Tests carried out, whenever a change is made in the composition or in the size/series in order to establish the suitability and the performance capability of the pipes and fittings.

3.26.2 *Acceptance Tests*

Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

4 SYMBOLS

The following notations (symbols) shall apply in this standard:

d_n — nominal outside diameter

d_i — nominal inside diameter

d_e — outside diameter at any point

d_{em} — mean outside diameter

$d_{em, Max}$ — maximum mean outside diameter

$d_{em, Min}$ — minimum mean outside diameter

d_s — inside diameter of socket

d_{sm} — mean inside diameter of socket

d_{n1} — nominal outside diameter of the main of a branch/saddle branch

d_{n2} — nominal outside diameter of the branch of a branch/saddle branch

SDR — standard dimension ratio

e — wall thickness at any point

e_m — mean wall thickness

e_{Max} — maximum wall thickness at any point

e_{Min} — minimum wall thickness at any point

$e_{m, Max}$ — maximum mean wall thickness

e_c — construction height

A — length of engagement

C — depth of sealing zone

e_2 — wall thickness of the socket

e_3 — wall thickness of the groove

e_4 — wall thickness of the inside layer (waterway wall thickness)

L — axial cover by a saddle branch

$L_{1, Min}$ — minimum length of a spigot

Z_1 — design length of a fitting

Z_2 — design length of a fitting

Z_3 — design length of a fitting

α — nominal angle of a fitting

l — effective length of pipe

l_1 — length of spigot

l_2 — length of solvent cement socket

5 COMPOSITION OF THE MATERIAL

5.1 The material from which the pipe is produced shall consist substantially of polyvinyl chloride, to which may be added only those additives that are needed to facilitate the manufacture of components conforming to requirements of this standard. When tested as per Annex B of IS 15778, the content of PVC-U shall be at least 80 percent in mass fraction (equivalent to 45.6 percent chlorine content minimum) for pipes and 85 percent in mass fraction (equivalent to 48.4 percent chlorine content minimum) for injection moulded fittings. A further reduction of the PVC-U content (for foam core pipes only) is permitted ≥ 60 percent by mass (equivalent to 34.2 percent chlorine content minimum) for intermediate layer and ≥ 75 percent by mass fractions (equivalent to 42.7 percent chlorine content minimum) in other layers provided the PVC-U is substituted by $CaCO_3$ confirming to the following:

a) The composition of the $CaCO_3$, before coating if any, shall be as follows:
   1) Content of $CaCO_3$: ≥ 96 percent by mass fraction
   2) Content of $MgCO_3$: ≤ 4 percent mass fraction
   3) Content of $CaCO_3$ and $MgCO_3$ in total fraction : ≥ 98percent by mass fraction

b) The physical properties of the material shall be as follows:
   1) Mean particle size : ≤ 2.5 µm
   2) Top cut, D98 : ≤ 20 µm

NOTES

1 Machining of the test piece is allowed to get the intermediate and other layers separated.

2 A test report or conformity certificate may be obtained from the $CaCO_3$ manufacturer for above properties.

5.2 Pipes and fittings materials shall have the characteristics as given in Table 1.

5.3 When sealing rings are retained by means of retaining devices (rings or caps), the devices may be made from polymers other than PVC-U, provided they conform to the same functional dimensions and test requirements as applied to sockets with either loose or fixed sealing rings.

5.4 Clean, reprocessable material generated from manufacturer's own production and works testing of products according to this standard may be used, if it is derived from the same raw material as used for the relevant production. Reprocessable material obtained from external sources and recyclable material shall not be used. Manufacturers own rework material resulting from the original manufacturing of pipes and fittings is permissible. No other rework/recycled materials shall be used.

6 DESIGNATION OF WALL CONSTRUCTIONS AND EXAMPLES OF TYPICAL JOINTING METHODS

6.1 Wall Construction Designated as Type A

6.1.1 *Multilayer Construction or Hollow-Wall Construction with Axial Hollow Sections*

A pipe or fitting with a smooth internal and external surface and in which the outer and inner walls are connected by foamed intermediate layer of PVC-U or internal axial ribs of PVC-U, shall fall within this standard. Typical examples of such constructions are shown in Fig 1.

6.2 Designation

Pipes and fittings will be designated on the basis of its material/structural wall construction/nominal OD/ nominal ring stiffness such as:

PVC-U/Foamcore/OD/SN or PVC-U/Hollowcore/OD/SN

Table 1 Material Characteristics of PVC-U Pipes and Injection Moulded Fittings

(*Clause* 5.2)

Sl No.	**Characteristics**	**Circumferential Hoop Stress (σ)** MPa Min	**Test Duration (Minimum Holding Time)** h	**Method of Test, Ref to**	**Requirements**
(1)	(2)	(3)	(4)	(5)	(6)
i)	Resistance to internal hydrostatic pressure at 60ºC 1), 2), 3)	Pipe material (1) Fitting material (6.3)	1 000	IS 12235 (Part 8/Sec 3)	No seepage, cracking, bursting

NOTE — Required internal test pressure, in MPa, can be calculated as follow:

$$P = \frac{\sigma.2.e_{\mathrm{Min}}}{(d_{\partial m} - e_{\mathrm{Min}})}$$

where

σ = hoop stress, in Mpa;

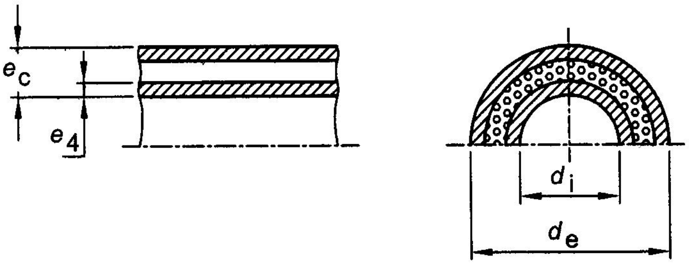
d_{em} = measured mean outside diameter, in mm; and

e_{Min} = measured minimum wall thickness of free length of test specimen, in mm.

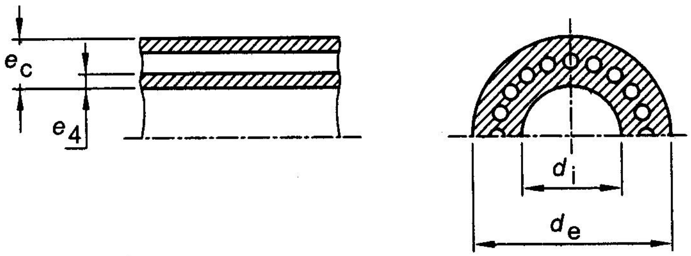
1) For extrusion compounds, this test shall be carried out in the form of a solid-wall pipe made from the relevant extrusion material.

2) For injection moulding compounds, this test shall be carried out in the form of an injection moulded or extruded sample in solid wall pipe form made from the relevant material.

3) Test not required for the intermediate layer of foam core pipes.



1A Foamcore Construction



1B Hollowcore Construction

FIG. 1 TYPICAL EXAMPLES FOR FOAMCORE/HOLLOWCORE STRUCTURED WALL CONSTRUCTION

6.3 DIMENSION OF PIPES AND FITTINGS

6.3.1 *Mean Outside Diameter*

The mean outside diameter, outside diameter at any point and tolerances shall be as given in Table 2 and shall be measured according to the method given in IS 12235 (Part 1).

6.3.2 *Wall Thickness*

The minimum wall thickness of inside layer ($e_{4,\,\text{Min}}$) shall be in accordance with Table 3.

6.3.3 *Length of Pipe*

The effective length (l) shall not be less than that specified by the manufacturer when measured as shown in Fig. 2.

6.3.4 *Dimensions of Integral Sockets and Spigot Ends*

The basic dimensions shall be in accordance with Fig. 2, 3, 4 and 5 and Tables 4 and 5.

6.3.4.1 *Wall thickness of sockets*

Wall thickness of sockets shall satisfy the following:

$$e_{2\text{Min}} = 0.9e \text{ and } e_{3\text{Min}} = 0.75e$$

Wall thickness $e_{3\text{Min}}$ applies only to those parts of the sealing ring zone where the fluid contained within the pipe comes into contact with the fluid that is beyond the designated ring seal point, walls thinner than e_3 are permitted.

Table 2 Outside Diameters and Tolerances
(*Clause* 6.3.1)

All dimensions in millimetres.

Sl No.	Nominal Outside Diameter, d_n	Mean Outside Diameter, d_{em}	
		Min	*Max*
(1)	(2)	(3)	(4)
i)	110	110.0	110.4
ii)	125	125.0	125.4
iii)	160	160.0	160.5
iv)	200	200.0	200.6
v)	250	250.0	250.8
vi)	315	315.0	316.0
vii)	400	400.0	401.2
viii)	500	500.0	501.5
ix)	630	630.0	631.9
x)	800	800.0	802.4
xi)	1 000	1 000.0	1 003.0
xii)	1 200	1 200.0	1 204.0

Table 3 Thickness of Inside Layers
(*Clause* 6.3.2)

All dimensions in millimetres.

Sl No.	Nominal Outside Diameter, d_n	Minimum Wall Thickness	
		Multilayer $e_{4,\,\text{Min}}$	Hollow wall $e_{4,\,\text{Min}}$
(1)	(2)	(3)	(4)
i)	110	0.4	0.6
ii)	125	0.4	0.6
iii)	160	0.5	0.8
iv)	200	0.6	1.0
v)	250	0.7	1.1
vi)	315	0.8	1.2
vii)	400	1.0	1.5
viii)	500	1.3	2.1
ix)	630	1.6	2.6
x)	800	2.0	3.0
xi)	1 000	2.5	3.5
xii)	1200	2.8	4.7

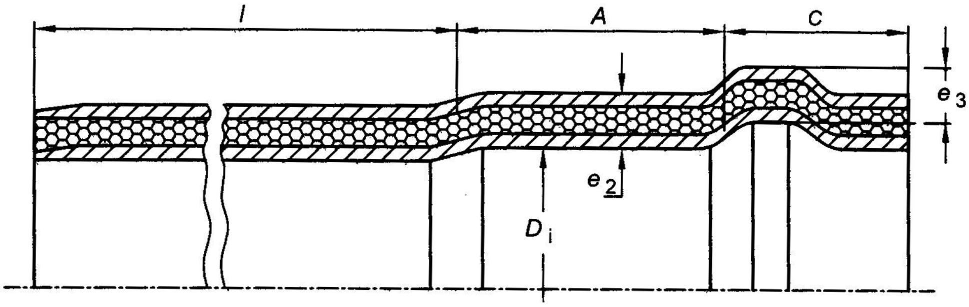


FIG. 2 BASIC DIMENSIONS OF INTEGRAL SOCKETS AND SPIGOTS FOR ENDS FOR ELASTOMERIC SEALING RING JOINTS

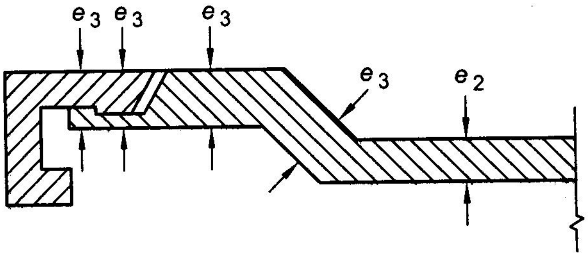


FIG. 3 EXAMPLE OF SEAL RETAINING CAP AND CALCULATION OF THE WALL THICKNESS OF SOCKETS

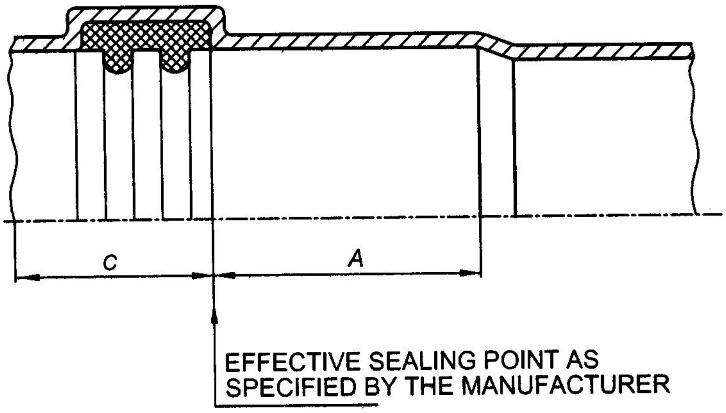


FIG. 4 EXAMPLES FOR MEASURING THE EFFECTIVE SEALING POINTS

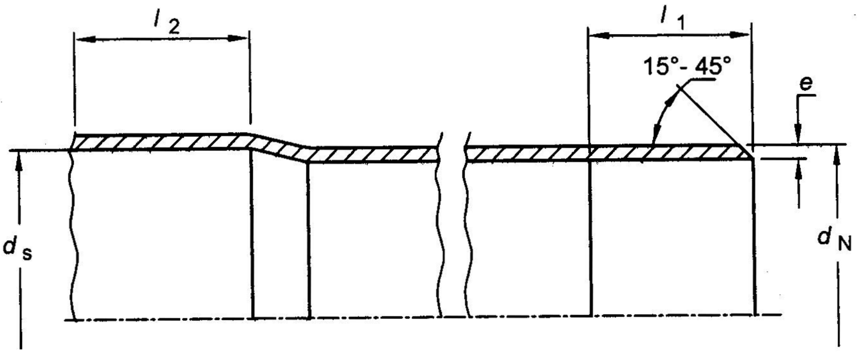


FIG. 5 BASIC DIMENSIONS FOR INTEGRAL SOCKETS AND SPIGOTS FOR SOLVENT-CEMENTED JOINTS

Table 4 Dimensions of Elastomeric Sealing Ring Sockets and Spigot ends

(*Clause* 6.3.4)

All dimensions in millimetres.

Sl No.	**Nominal Diameter**	**Socket**			**Spigot End**
	d_n	$D_{sm\ Min}$	A_{Min}	C_{Max}	$l_{1\ Min}$
(1)	(2)	(3)	(4)	(5)	(6)
i)	110	110.4	32	26	60
ii)	125	125.4	35	26	67
iii)	160	160.5	42	32	81
iv)	200	200.6	50	40	99
v)	250	250.8	55	70	125
vi)	315	316.0	62	70	132
vii)	400	401.2	70	80	150
viii)	500	501.5	80	80[1]	160
ix)	630	631.9	93	95[1]	188
x)	800	802.4	110	110[1]	220
xi)	1 000	1 003.0	130	140[1]	270
xii)	1 200	—	150	—	—

NOTES

1 A_{Min} for $d_n \geq 200$ mm, shall be $0.2d_n + 10$ mm.

2 A_{Min} for $d_n \geq 250$ mm, shall be $0.1d_n + 30$ mm.

[1] Higher values for *C* are allowed, provided the manufacturer states in his documentation the actual value of the $l_1$min required by the equation $l_{1Min} = A_{Min} + C$.

Table 5 Dimensions of Sockets and Spigot Ends for Sliding Socket Joints

(*Clause* 6.3.4)

All dimensions in millimetres.

Sl No.	**Nominal Diameter**	**Socket**			**Spigot End**
	d_n	$d_{sm\,Min}$	$d_{sm\,Max}$	$l_{2\,Min}$	l_{1Min}
(1)	(2)	(3)	(4)	(5)	(6)
i)	110	110.1	110.4	61	71
ii)	125	125.1	125.4	68.5	79
iii)	160	160.2	160.4	86	96
iv)	200	200.3	200.6	106.0	116
v)	250	250.4	250.8	131.0	141
vi)	315	315.4	316.0	163.5	193
vii)	400	400.4	401.0	206.0	246
viii)	500	500.4	501.0	256.0	286
ix)	630	630.4	631.0	321.0	351
x)	800	800.4	802.0	406.0	436
xi)	1 000	1 000.5	1 002.5	506.0	540
xii)	1 200	—	—	—	—

NOTE — For solvent cement sockets, the manufacturer shall declare whether the socket is designed tapered or parallel. If they are parallel, or near parallel, the mean outside diameter of the socket, d_{sm}, shall apply over the entire length of the socket. If the socket is tapered, then the limits for d_{sm} apply at the midpoint of the socket with a maximum taper of 0°30'.

If retaining caps or rings are provided, they can be made to other designs or from polymers other than unplasticized polyvinyl chloride, provided that the finished joint conforms to the same functional test requirements.

When a sealing ring is retained by means of a retaining ring or cap, the wall thickness of the area shall be calculated by addition of the wall thickness at the corresponding places of the socket and the retaining ring or cap (*see* Fig. 3). In all the cases, the components shall meet the functional test requirements.

6.3.4.2 *Fabricated fittings*

The wall thickness of the body of fittings fabricated from pipes shall conform to the requirements of the corresponding pipe. Wall thickness reduction due to the process is permitted provided there is conformance with the performance requirements as given in **6.3.4.1**.

The joining design shall confirm to **6.3.4.1**. The socket and spigot dimensions shall comply with Table 4 and Table 5.

6.3.4.3 *Rotational moulded fittings*

The minimum wall thickness in the body of rotational moulded fittings e_{4Min} shall be 1.25 times the values specified for injection moulded fittings, rounded to the next higher 0.1mm.

If the rotational moulded fittings have a solid plain spigot and/or socket, the minimum required wall thickness e_2 and e_3 as applicable shall be 1.25 times the values derived from **6.3.4.1**.

6.3.4.4 *Type of fittings*

The type of fittings covered in this standard are given in Fig. 6.

7 PHYSICAL CHARACTERISTICS FOR PIPES

7.1 Appearance

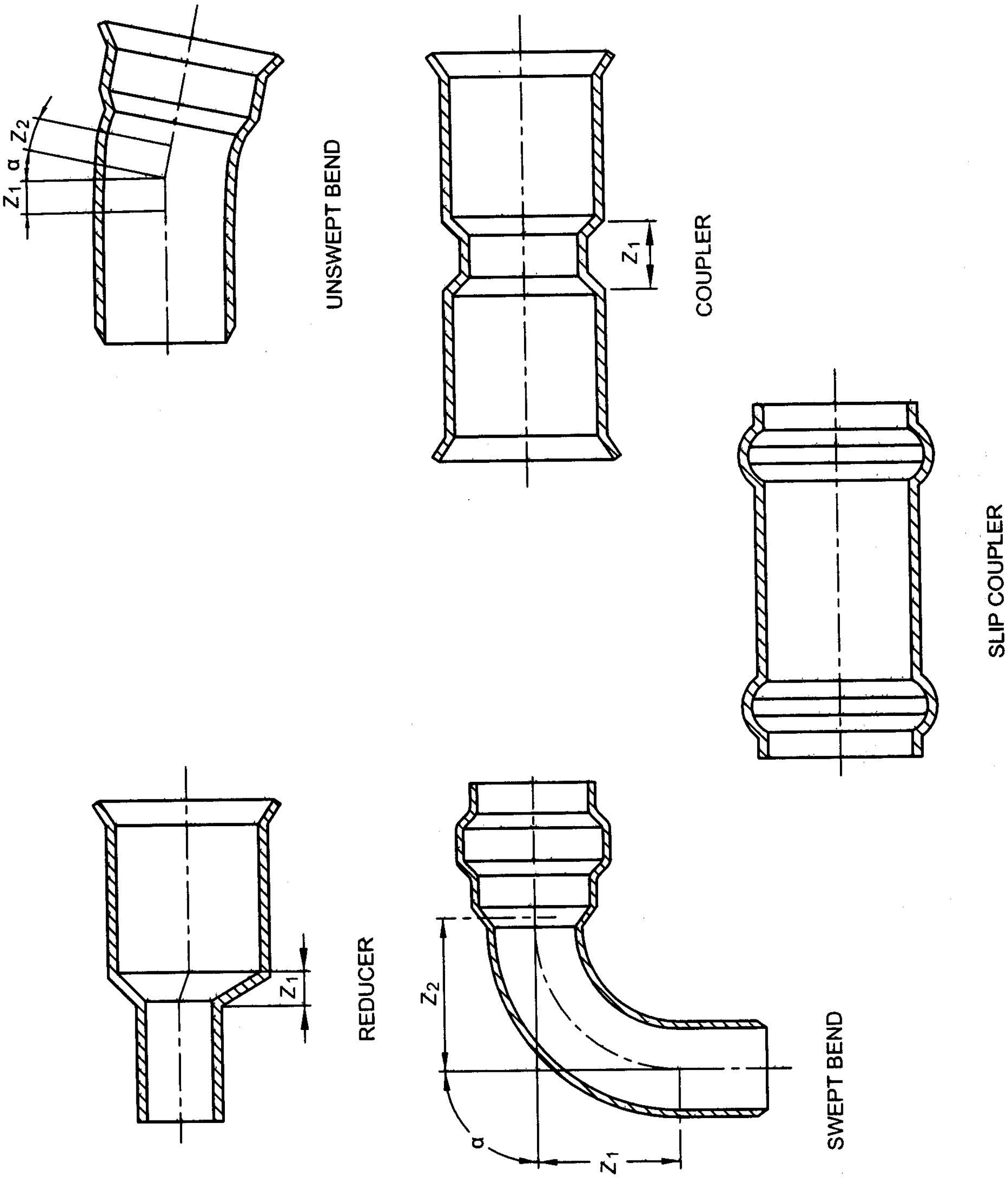
The pipes shall be homogeneous throughout and essentially uniform in colour and density. The pipe wall shall be free of cracks, holes, blisters, voids, foreign inclusions and other defects that are visible with naked eye and that may affect the wall integrity. Slight shallow longitudinal grooves or irregularities in the pipe shall be permissible, provided the wall thickness remains within permissible limits. The pipe ends shall be cleanly cut and reasonably square to the axis of pipe.

7.2 Colour

The inner and outer layer of pipes shall be coloured throughout. The outside layer of pipes should preferably be black or orange brown or grey.

7.3 Vicat Softening Temperature for Pipes

The Vicat softening temperature, when determined according to test method prescribed in IS 12235 (Part 2) shall not be less than 79°C. It is not applicable to the foamed part of pipe, if e_4 is less than 1.8 mm. This test shall be carried out on a profile extruded from the material. Indirect testing may be carried out using the pipe sample in the case of foamed part of pipe.



NOTE — Other type of fittings are also allowed provided they meet the requirements of this standard.

FIG. 6 TYPES OF FITTINGS

7.4 Resistance to Dichloromethane

When tested according to test method prescribed in IS 12235 (Part 11), in a thermo controlled dichloromethane bath for 30 min at a temperature of 15°C, there shall be no sign of any attack on the pipe surface. However, this test is not applicable to the foamed part of a pipe and is applicable to pipes having wall thickness e_4 greater than 3 mm.

7.5 Longitudinal Reversion

The longitudinal reversion, when tested according to the method prescribed in IS 12235 (Part 5), shall not exceed ±5 percent. In case of socket-ended pipe, this test shall be carried out on the plain portion of the pipe taken at least 100 mm away from the root of the socket. The pipe shall not exhibit any blisters, bubbles or cracks on completion of the test. Bubbles in the foamed structure are exempt from these requirements.

8 PHYSICAL CHARACTERISTICS OF FITTINGS

8.1 Appearance and Colour

The fittings shall conform to the requirements of appearance and colour as specified for pipes in **7.1** and **7.2**.

8.2 Vicat Softening Temperature for Fittings

The Vicat softening temperature, when determined according to test method prescribed in IS 12235 (Part 2) shall not be less than 77°C. It is only applicable to injection moulded fittings and injection moulded component for fabricated fittings.

8.3 Effect of Heating (Stress Relief Test)

When tested in accordance with IS 12235 (Part 6), the fittings shall not show the delamination as mentioned below:

a) Within a radius of 15 times the wall thickness around the injection point(s), the depth of the cracks, delamination or blisters shall not exceed 50 percent of the wall thickness at that point.
b) Within a distance of 10 times the wall thickness from the diaphragm zone, the depth of the cracks, delamination or blisters shall not exceed 50 percent of the wall thickness at that point.
c) Within a distance of 10 times the wall thickness from the ring gate, the length of the cracks running through the overall thickness of the wall shall not exceed 50 percent of the wall thickness at that point.
d) The weld line shall not have opened more than 50 percent of the wall thickness at that line.
e) In all other parts of the surface, the depth of cracks and delaminations shall not exceed 30 percent of the wall thickness at that point. Blisters shall not exceed a length of 10 times the wall thickness.

NOTE — For the wall thickness, the maximum measured wall thickness for the fittings, excluding e_c shall be taken.

9 MECHANICAL CHARACTERISTICS OF PIPES

9.1 Ring Stiffness

The pipes shall be designated in one of the following ring stiffness classes (SN):

a) DN ≤ 500 : SN 4, SN 8 or SN16
b) DN > 500 : SN 2, SN 4, SN 8 or SN 16

For DN ≥ 500 the manufacturer's guaranteed minimum stiffness, between the SN values, of a component may be used for calculation purposes only. Such pipes shall be classified and marked as the next lower stiffness values.

When tested according to the method described in Annex C, the ring stiffness of the pipe shall be as stated in Table 6.

9.2 Resistance to External Blows at 0°C

When tested according to the method prescribed in IS 12235 (Part 9) with test parameters mentioned in Table 7, the pipe shall have a true impact rate of not more than 10 percent. In case of socket ended pipes, this test shall be carried out on the plain portion of the pipe taken at least 100 mm away from the root of the socket.

9.3 Ring Flexibility

When tested as per procedure described in Annex D, on deflection of 30 percent of d_{em}, on a pipe sample of size 300 ± 10 mm and visually inspected without magnification, requirements in (a) and (b) shall be satisfied during the test and those in (c) to (e) shall be satisfied after the test.

a) There shall be no decrease of the measured force.
b) There shall be no cracking in any part of the wall structure.
c) There shall be no wall delamination with the exception of possible delamination between the outside and inside wall of double wall pipes occurring in reduced welding zone in the ends of the test piece.
d) There shall be no types of rupture in the test piece.
e) There shall be no permanent buckling in any part of the structure of the pipe wall, including depressions and craters shall not occur in any direction.

Table 6 Ring Stiffness of Pipes
(*Clause* 9.1)

Sl No. (1)	Stiffness Class (2)	Ring Stiffness kN/m^2 (3)
i)	SN 2	≥ 2
ii)	SN 4	≥ 4
iii)	SN 8	≥ 8
iv)	SN 16	≥ 16

Table 7 Weight of Striker and Height of Fall
(*Clause* 9.2)

Sl No. (1)	Diameter of Pipe mm (2)	Height m (3)	Weight kg (4)
i)	110	1.6	0.8
ii)	125	2.0	0.8
iii)	160	2.0	1.0
iv)	200	2.0	1.6
v)	250	2.0	2.0
vi)	315	2.0	2.5
vii)	>315	2.0	3.2

9.4 Creep Ratio

When tested as per procedure given in Annex E, creep ratio for structured wall PVC-U pipes shall be ≤ 2.5 at 2 years extrapolation.

10 MECHANICAL CHARACTERISTICS OF THE FITTINGS

The fittings shall be designated in one of the following ring stiffness classes (SN):

a) DN ≥ 500 : SN 4, SN 8 or SN16
b) DN > 500 : SN 2, SN 4, SN 8 or SN 16

For DN ≥ 500 the manufacturer's guaranteed minimum stiffness, between the SN values, of a component may be used for calculation purposes only. Such fittings shall be classified and marked as the next lower stiffness values.

When a fitting, in accordance with this standard, has the same wall construction as a corresponding pipe, the stiffness of the fitting, because of its geometry, is equal to or greater than that of the pipe. Such fittings can be classified with the same stiffness class as that pipe without testing the stiffness.

10.1 Impact Strength of Injection Moulded and Fabricated Fittings

For this test, fittings shall be conditioned for 30 min at a temperature of 0 ± 1°C. Within 10 s after the conditioning treatment, five fittings of each diameter and type shall be dropped freely in various positions on to a flat concrete floor from a height of 1 ± 0.05 m.

If none of the specimen is damaged in the test, the fittings shall be accepted. If one fitting is damaged the test shall be repeated with five other fittings. None of these last five fittings shall be damaged.

NOTE — In the context of this test, 'damage' means any visible split or any complete breakage in the body of the fitting. Surface scratches, scuffing, or chipping of edge which may occur in the test does not constitute damage.

11 JOINTS

11.1 Elastomeric Sealing Rings

Elastomeric sealing rings shall be free from substances (for example plasticizers) that can have a detrimental effect on the pipes or fittings, used in conjunction with pipes.

The design of the profile and dimensions of the sealing ring is left to the manufacturer, as long as the pipe with the sealing ring meets the requirements of this standard. Where the design of the socket is such that the sealing ring is not firmly fixed in position, the housing for the ring shall be so designed as to minimize the possibility of the ring being dislodged during insertion of the pipe (or spigot or fitting) to complete the joint.

Elastomeric sealing rings shall be in accordance with one of the type (Type 1 to Type 6) of IS 5382. The manufacturer has to, however, specify the type of sealing ring (namely, Type 1, 2, 3, 4, 5 or 6) that is being offered.

NOTE — A test report or conformity certificate may be obtained from the manufacturer of the sealing ring for conformity to IS 5382.

11.2 Solvent Cement

The solvent cement used shall conform to the requirements laid down in IS 14182.

12 PERFORMANCE REQUIREMENTS

12.1 Elastomeric Sealing Ring Joints

12.1.1 *Tightness of Elastomeric Sealing Ring Joints (Water Pressure)*

When tested according to the method described in IS 12235 (Part 8/Sec 2), the joint, when assembled according to the manufacturer's instructions and subjected to an angular deflection, α of minimum 2° as well as a diametric deflection (distortion) of 5 percent of the outer diameter, shall withstand an internal pressure of up to and including 0.05 MPa (0.5 bar) for a minimum of 15 min without leakage.

12.1.2 *Tightness of Elastomeric Sealing Ring Joints (Internal Vacuum)*

When tested according to the method described in IS 12235 (Part 8/Sec 3), the joint, when assembled according to the manufacturer's instructions and subjected to an angular deflection, α of minimum 2° as well as a diametric deflection (distortion) of 5 percent of the outer diameter, shall withstand an internal negative pressure (internal vacuum) of up to and including 0.03 MPa (0.3 bar) for a minimum of 15 min without leakage.

12.1.3 *Resistance to Combined Temperature Cycling and External Loading*

When tested in accordance to Annex D of IS 16098 (Part 2), the joint shall meet the following:

a) Vertical deformation : ≤ 9 percent
b) Deviation from the surface evenness in bottom : ≤ 3 mm
c) Radius of bottom : ≥ 80 percent of original
d) Opening of weld line : ≤ 20 percent of wall thickness
e) Tightness at 35 kpa (0.35 bar)/15 min : no leakage allowed

12.2 Solvent Cemented Joints

12.2.1 *Tightness of Solvent Cemented Ring Joints*

When assembled according to the manufacturer's instructions, the joint shall withstand an internal pressure of up to and including 0.05 MPa (0.5 bar) for a minimum period of 15 min without leakage.

12.2.2 *Tightness of Solvent Cemented Joints (Internal Vacuum)*

When assembled according to the manufacturer's instructions, the joint shall withstand an internal negative pressure (internal vacuum) of up to and including 0.03 MPa (0.3 bar) for a minimum period of 15 min without leakage.

NOTE — Deflection and distortion shall not apply to solvent-cemented joints.

13 SAMPLING AND CRITERIA FOR CONFORMITY

13.1 Acceptance Tests

13.1.1 Acceptance tests (*see* Tables 8 and 9) shall be carried out on samples selected from a lot for the purpose of acceptance of the lot.

13.1.2 All pipes and fittings in a single consignment of the same class, size and manufactured under essentially similar conditions shall constitute a lot.

13.1.3 For ascertaining the conformity of the lot to the requirements of the standard, samples shall be tested from each lot separately.

13.2 Acceptance Tests for Pipes

13.2.1 *Visual and Dimensional Requirements*

13.2.1.1 The number of test samples taken from a lot shall depend on the size of the lot and shall be in accordance with Table 10.

The sampling procedure and criteria for conformity shall be as given in **13.2.1.2** and **13.2.1.3**.

13.2.1.2 These pipes shall be tested at random from the lot and in order to ensure the randomness of the selection, a random number table shall be used. For guidance and use of random number tables, IS 4905 may be referred to. In the absence of a random number table, the following procedure may be adopted:

Starting from any pipe in the lot, count 1, 2, 3… and so on up to *r*, where *r* is the integral part of *N*/*n*, *N* being the number of pipes in the lot, and *n* the number of pipes in the sample. Every *r*th pipe so counted shall be withdrawn so as to constitute the required sample size.

13.2.1.3 The number of pipes given for the first sample in col 4 of Table 10, shall be taken from the lot and examined for visual and dimensional requirements given in **6.3**, **7.1** and **7.2**. A pipe failing to satisfy any of these requirements shall be considered as defective. The lot shall be deemed to have satisfied these requirements, if the number of defectives found in the first sample is less than or equal to the corresponding acceptance number given in col 6 of Table 10. The lot shall be deemed not to have met the requirements, if the number of defectives found in the first sample is greater than or equal to the corresponding rejection number given in col 7 of Table 10. If however, the number of defectives found in the first sample lies between the corresponding acceptance or rejection numbers given in col 6 and col 7 of Table 10, a second sample of the size given in col 4 of Table 10 shall be taken and examined for these requirements. The lot shall be considered to have satisfied these requirements, if the cumulative number of defectives is less than or equal to the corresponding acceptance number given in col 6 of Table 10, otherwise not.

13.2.2 *Resistance to Dichloromethane*

13.2.2.1 The procedure adopted for sampling and criteria for conformity shall be as per Table 8.

13.2.3 *Reversion Test*

13.2.3.1 The lot, having satisfied visual and dimensional requirements, shall be tested for reversion.

13.2.3.2 The procedure adopted for sampling and criteria for conformity shall be as per Table 8.

Table 8 Acceptance Test for Pipes

(*Clauses* 13.1.1 *and* 13.2.2.1)

Sl No. (1)	Test (2)	Sample Size (3)	Requirement, Ref to Clause (4)
i)	Dimensions and visual appearance	See Table 10	6.3
ii)	Resistance to dichloro methane	See Table 11	7.4
iii)	Reversion	See Table 11	7.5
iv)	Ring stiffness	See Table 11	9.1
v)	Resistance to external blows at 0 °C	See Table 11	9.2
vi)	Tightness of elastomeric seal ring joints (water pressure)	See Table 11	12.0

Table 9 Acceptance Test for Fittings

(*Clause* 13.1.1)

Sl No. (1)	Test (2)	Sample Size (3)	Requirement, Ref to Clause (4)
i)	Dimensions and visual appearance	See Table 10	6.3
ii)	Stress relief test	See Table 11	8.2
iii)	Resistance to external blows at 0°C	See Table 11	10.1
iv)	Tightness of elastomeric seal ring joints (water pressure)	See Table 11	12.0

Table 10 Scale of Sampling for Visual Appearance and Dimensional Requirements

(*Clauses* 13.2.1.1 *and* 13.2.1.3)

Sl No. (1)	Number of Pipes in the Lot (2)	Sample Number (3)	Sample Size (4)	Cumulative Sample Size (5)	Acceptance Number (6)	Rejection Number (7)
i)	Up to 1 000	First	13	13	0	2
		Second	13	26	1	2
ii)	1 001-3 000	First	20	20	0	2
		Second	20	40	1	2
iii)	3 001-10 000	First	32	32	0	3
		Second	32	64	3	4
iv)	10 001 and above	First	50	50	1	4
		Second	50	100	4	5

13.2.4 *Ring Stiffness*

13.2.4.1 The lot, having been found satisfactory according to **13.2.1, 13.2.2** and **13.2.3** shall be tested for ring stiffness.

13.2.4.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be as per Table 8.

13.2.5 *Resistance to External Blows at 0°C*

13.2.5.1 The lot, having been found satisfactory according to **13.2.1, 13.2.2** and **13.2.3** shall be tested for resistance to external blows at 0°C.

13.2.5.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be as per Table 8.

13.2.6 *Tightness of Elastomeric Seal Ring Joints (Water Pressure)*

13.2.6.1 The lot, having been found satisfactory according to **13.2.1, 13.2.2** and **13.2.3** shall be tested for tightness for elastomeric seal ring joints (water pressure).

13.2.6.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be as per Table 8.

13.3 Acceptance Tests for Fittings

13.3.1 *Visual and Dimensional Requirements*

The number of test samples, sampling procedure and criteria for conformity shall be in accordance with **13.2.1**.

13.3.2 *Stress Relief Test*

The lot, found satisfactory according to **13.3.1** shall be tested for stress relief test. The procedure adopted for sampling and criteria for conformity shall be as per Table 9.

13.3.3 *Resistance to External Blow at 0°C*

The lot, found satisfactory according to **13.3.1** and **13.3.2** shall be tested for resistance to external blow at 0° C. The procedure adopted for sampling and criteria for conformity shall be as per Table 9.

13.3.4 *Tightness of Elastomeric Seal Ring Joints (Water Pressure)*

Table 11 Scale of Sampling for Acceptance Tests for Pipes and Fittings Other than Visual Appearance and Dimensional Requirements

All dimensions in millimetres.

(*Tables* 8 *and* 9)

Sl No. (1)	Number of Pipes in the Lot (2)	Sample Number (3)	Sample Size (4)	Cumulative Sample Size (5)	Acceptance Number (6)	Rejection Number (7)
i)	Up to 1 000	First	3	3	0	2
		Second	3	6	1	2
ii)	1 001-3 000	First	5	5	0	2
		Second	5	10	1	2
iii)	3 001 and above	First	7	7	0	2
		Second	7	14	1	2

NOTE — The numbers mentioned in col 3 to col 6 represents the number of times the test is to be carried out and do not represent either the number of samples or the number of blows or the number of failures.

The lot, found satisfactory according to **13.3.1**, **13.3.2** and **13.3.3** shall be tested for tightness of elastomeric seal ring joint. The procedure adopted for sampling and criteria for conformity shall be as per Table 9.

14 TYPE TESTS

14.1 Type Tests for Pipes

14.1.1 Type tests (*see* Table 12) are intended to prove the suitability and performance of a new composition or a new size of pipe. Such tests, therefore, need to be applied only when a change is made in the polymer composition or when a new size is to be introduced.

14.1.2 *Vicat Softening Temperature*

14.1.2.1 The lot, having satisfied the visual and dimensional requirements, shall be tested for Vicat softening temperature.

14.1.2.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be the same as given in Table 12.

14.1.3 *Ring Flexibility*

14.1.3.1 The lot, having satisfied the visual and dimensional requirements, shall be tested for the ring flexibility test.

Table 12 Type Test for Pipes

(*Clause* 14.1.1)

Sl No. (1)	Test (2)	Sample Size (3)	Requirement, Ref to Clause (4)
i)	Vicat softening point	3	7.3
ii)	Ring flexibility	3	9.3
iii)	Creep ratio	3	9.4
iv)	Resistance to combined temperature cycling and external loading	3	12.1.3
v)	Tightness of elastomeric seal ring joints (internal vacuum)	3	12

14.1.3.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be as per Table 12.

14.1.4 *Resistance to Internal Hydrostatic Pressure (Type Test)*

14.1.4.1 For this test, the manufacturer or the supplier shall supply/furnish to the testing authority, one sample of pipe as mentioned in **5.2**.

14.1.4.2 The sample so selected shall be tested for compliance with the requirements of internal hydrostatic pressure test as given in Table 1.

14.1.4.3 If the sample passes the requirements of the quality test, the material under consideration shall be considered to be eligible for type approval, which shall be normally valid for a period of one year.

14.1.4.4 In case the sample fails in this test, the testing authority, at its discretion, may call for fresh sample not exceeding the original number and subject them to the type test. If, in the repeat test, no failure occurs, the material shall be considered for type approval. If the sample fails in the repeat tests, the type of material shall not be approved. The manufacturer or the supplier may be asked to improve the material and resubmit the product for type approval.

14.1.4.5 At the end of the validity period (normally one year) or earlier, if necessary, the testing authority may call for fresh sample for type test for the purpose of type approval.

14.1.5 *Creep Ratio*

14.1.5.1 For this test, the manufacturer or the supplier shall supply/furnish to the testing authority, three samples of pipes of different diameters and different classes, selected preferably from a regular production lot.

14.1.5.2 Three samples so selected shall be tested for compliance with the requirements of the test given in **9.4**.

14.1.5.3 If all the three samples pass the requirements of the quality test, the type of pipe under consideration shall be considered to be eligible for type approval, which shall be normally valid for a period of three year.

14.1.5.4 In case any of the samples fail this test, the testing authority, at its discretion, may call for fresh samples not exceeding the original number and subject them to the type test. If, in the repeat test, no single failure occurs, type of pipe shall be considered for type approval. If any of the samples fails in the repeat tests, the type of pipe shall not be approved. The manufacturer or the supplier may be asked to improve the design and resubmit the product for type approval.

14.1.6 *Resistance to Combined Temperature Cycling and External Loading*

For this test, the manufacturer or the supplier shall supply/furnish to the testing authority, three samples of pipes of different diameters and different classes, selected preferably from a regular production lot.

14.1.6.1 Three samples so selected shall be tested for compliance with the requirements of the type test given in **12.1.3**.

14.1.6.2 If all the three samples pass the requirements of the quality test, the type of pipe under consideration shall be considered to be eligible for type approval, which shall be normally valid for a period of three year.

14.1.6.3 In case any of the samples fail this test, the testing authority, at its discretion, may call for fresh samples not exceeding the original number and subject them to the type test. If, in the repeat test, no single failure occurs, type of pipe shall be considered for type approval. If any of the samples fails in the repeat tests, the type of pipe shall not be approved. The manufacturer or the supplier may be asked to improve the design and resubmit the product for type approval.

14.1.6.4 At the end of the validity period (normally three year) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

14.2 Type Test for Fittings

14.2.1 Type tests (*see* Table 13) are intended to prove the suitability and performance of a new composition or a new size of fittings. Such tests, therefore, need to be applied only when a change is made in the polymer composition or when a new size is to be introduced.

14.2.2 *Vicat Softening Temperature*

14.2.2.1 The lot, having satisfied the visual and dimensional requirements, shall be tested for Vicat softening temperature.

Table 13 Type Test for Fittings

(*Clause* 14.2.1)

Sl No. (1)	Test (2)	Sample Size (3)	Requirement, Ref to Clause (4)
i)	Vicat softening point	3	7.3
ii)	Tightness of elastomeric seal ring joints (internal vacuum)	3	12

14.2.2.2 For this purpose, the procedure adopted for sampling and criteria for conformity shall be the same as given in Table 13.

14.2.3 *Tightness of Elastomeric Seal Ring Joints — Air Pressure*

The lot, having satisfied the visual and dimensional requirements, shall be tested for tightness of elastomeric seal ring joint. The procedure adopted for sampling and criteria for conformity shall be as per Table 13.

15 MARKING

15.1 Pipes

15.1.1 Each pipe shall be clearly and indelibly marked in ink/paint or hot embossed on white base at intervals of not more than 2 m, but at least once per pipe, in the colour indicated in **15.1.3** with the information given in **15.1.2**. The marking shall be legible without magnification. The marking shall not initiate cracks or other type of defects which adversely influence the performance of the pipe. Marking by indentation reducing the wall thickness by not more than 0.15 mm shall be deemed to conform to this clause without infringing the requirements for the wall thickness given in **6.3.2**.

15.1.2 The pipes shall be marked with the following information:

a) Manufacturer's name/Trade-mark;
b) Outside diameter;
c) Stiffness class and SDR;
d) Material, for example PVC-U; and
e) Batch number or Lot number.

15.1.3 The colour of marking shall be such that it differs from the basic colour of the pipe.

15.2 Fittings

15.2.1 Each fitting shall be labelled or printed or formed directly in such a way that after storage, weathering, handling and installation legibility of markings is maintained. Marking shall not initiate cracks or other types of defect that adversely influence the performance of the fittings.

15.2.2 The fittings shall be marked with the following information:

a) Manufacturer's name/Trade-mark;
b) Nominal diameter;
c) Stiffness class;
d) Material, for example PVC-U; and
e) Nominal angle (if any).

15.3 BIS Certification Marking

Each pipe or fittings may also be marked with the Standard Mark.

15.3.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the license for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Foreword*)

CREEP IN THERMOPLASTIC MATERIAL

A-1 Plastics pipes subjected to a constant load will be deflected when installed in the ground with an initial deflection, which can be estimated using the stiffness of the pipe, this stiffness, expressed as S, can be determined, in kN/m^2 by using the test method described in Annex E and with the following equation:

$$S = \left(0.018\,6 + 0.025\,{}^{y}\!/_{d_\mathrm{i}}\right) \cdot {}^{F}\!/_{L.y}$$

where

F = force needed to obtain the required deflection, in kN;
L = length of the test ring, in m; and
y = deflection of the ring, in m.

The stiffness of a pipe ring of constant cross-section can also be calculated from the following equation:

$$S = \frac{EI}{D^3}$$

where

E = modulus of elasticity of the material;
I = moment of inertia; and
D = mean diameter of the test ring.

Plastics pipes subjected to a constant load in laboratory test will show an increasing deflection with time owing to creep of the material.

A-2 At the molecular level, plastics materials can be considered to be built up from a great number of long chains. When a force is applied to the material, the chains deform immediately, giving the initial deflection.

When the material is subjected to a constant load, the chains will move relative to each other under the influence of that force, causing creep, a continuously increasing deformation. The structure of the chain does not change, therefore the material still shows the same immediate reaction when at some point in time after application of a constant load, this load is increased.

A-3 For design purposes, it is necessary to know the deflection of the pipe immediately after installation and over the long term.

An estimate of the initial deflection can be obtained using the stiffness, S of the pipe.

A rough indication of the long term (theoretical) deflection under constant load was formerly calculated using the specific tangential end stiffness (STES) of the pipe, taking into account the behaviours of the material surrounding the pipe. The STES was the long term stiffness, obtained by substituting, in place of the modulus of elasticity of the material in equation (*see* **D-1**), the creep modulus (apparent modulus), which is the initial modulus of the material divided by the creep ratio γ, thus giving,

$$\text{STES} = {}^{S}\!/_{\gamma}$$

The results of the approach can be interpreted to mean that the modulus of elasticity will decrease with time. This can cause confusion and may create the impression that plastics pipes are unsuitable for buried application.

In order to avoid such confusion, the preferred method for conditioning creep ratio is calculated using the following equation:

$$\gamma = \frac{Y_2 \left[0.018\,6 + 0.025 \left({}^{y_0}\!/_{d_i} \right) \right]}{y_0 \left[0.018\,6 + 0.025 \left({}^{Y_2}\!/_{d_i} \right) \right]}$$

NOTE — In practice, the nominal stiffness SN can be used.

ANNEX B

(*Foreword*)

RECOMMENDED REQUIREMENTS FOR TRENCH

B-1 TYPES OF TRENCH

B-1.1 General

The density of the backfill material, the width of the trench at the crown of the pipe, *b*, and the nominal outside diameter of the pipe, *D*, all influence the loads imposed on the pipe. In addition, the load on the pipe is also affected by the ratio *h, l, b* and the properties of the backfill material.

Because of the important role played by the bedding and sidefill in helping to support the loads superimposed on the pipes, it is important to know the trench design. It is useful, therefore, that the installer be aware of the main types of trenches. These are given in **B-5.1.2** to **B-5.1.5**.

B-1.2 Narrow Trench

This trench is as described in Fig. 7.

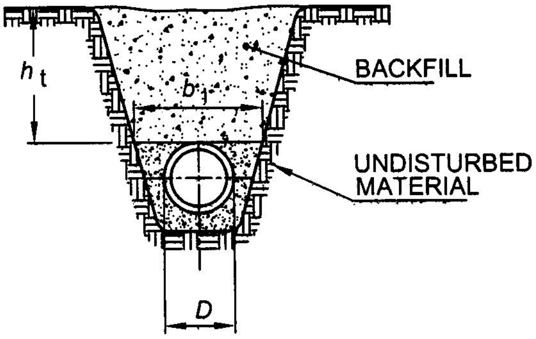


FIG. 7 NARROW TRENCH

B-1.3 Embankment — Positive Projection

In this type of trench (*see* Fig. 8), the crown of the pipe projects above the undisturbed ground level.

The absence of undisturbed trench sides and the settlement of the made up ground relative to that of the natural ground lead to loads greater than those which occur in a narrow trench.

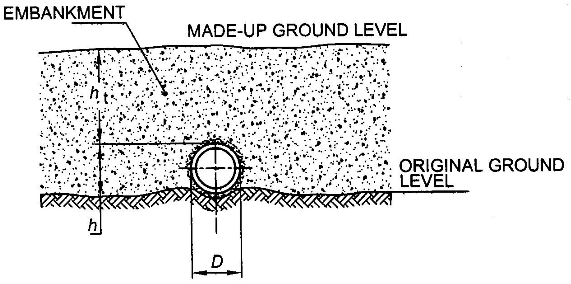


FIG. 8 EMBANKMENT — POSITIVE PROJECTION

B-1.4 Embankment — Negative Projection

A wide trench gives rise to loads greater than those which occur in a narrow trench owing to the greater mass of backfill bearing on the pipe, although friction between the undisturbed trench side and the backfill reduces the load to some extent. The load will be generally less than that which occurs in the negative projection embankment owing to the absence of infill and therefore the absence of relative settlement between the natural ground level and the infill material. This type of trench is shown in Fig. 9.

B-1.5 Wide Trench

A wide trench (*see* Fig. 10) gives rise to loads greater than those which occur in a narrow trench owing to the greater mass of backfill bearing on the pipe, although friction between the undisturbed trench side and the backfill reduces the load to some extent. The load will be generally less than that which occurs in the negative projection embankment owing to the absence of infill and therefore the absence of relative settlement between the natural ground level and the infill material.

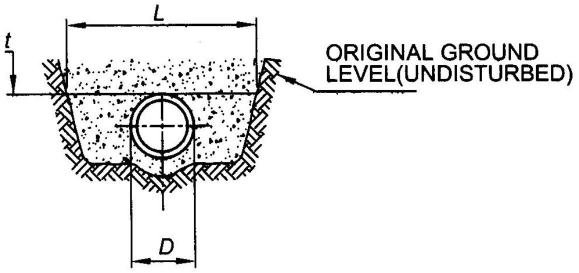


FIG. 9 EMBANKMENT — NEGATIVE PROJECTION

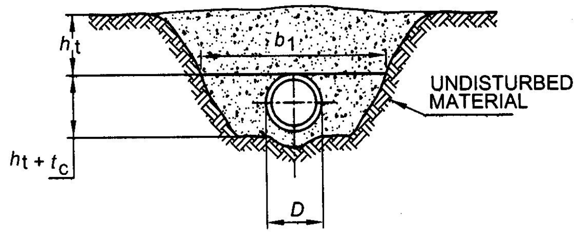


FIG. 10 WIDE TRENCH

B-1.6 Pipe Bedding and Sidefill

After the trench has been dug and trench bottom has been prepared, the bedding for the pipes should be prepared. The material excavated from the trench may be suitable as pipe bedding and sidefill (*see* **B-1.6.1**).

B-1.6.1 *Excavated Material*

If it is intended to use excavated material as bedding and sidefill to pipes, it should be homogeneous and should comply in general with the grading requirements, provided that the maximum particle size does not exceed 10 percent of the nominal pipe diameter or 60 mm, whichever is smaller. If excavated material does not comply with these requirements, it may be used provided that special instructions are given.

B-1.6.2 *Material not Excavated from Trench*

If suitable excavated material is not available, other material should be used. The most suitable material is gravel or broken stone from 6 mm to 16 mm in size, being easy to compact.

B-1.6.3 *Bedding*

A non-compacted layer of bedding material, of minimum thickness h_b = 100 mm (*see* Fig. 10) should be provided,

a) across the whole trench width for narrow trenches and negative projection embankments; and
b) on either side of the pipe for a minimum width of two pipe diameter, for other trenches.

B-1.7 Sidefilling and Backfilling

After the pipes have been laid, and any required testing has been carried out, side filling shall then proceed. The material used for side filling (*see* **B-1.6**) should be placed around the pipes and thoroughly compacted by hand in successive layers. This process should be carried out evenly on both sides of the pipe up to the centre line of the pipe (*see* Fig. 11, dimension l_1). It is most important that no voids are left under the pipes and that the sidefill is very firmly compacted between the pipes and the trench walls. Trench sheeting or timbering should be progressively withdrawn as this work proceeds.

The next layer (*see* Fig. 10, dimension l_2) of sidefill should be continued up to a height level with the top of the pipe. This layer should be achieved by successively depositing and compacting thin layers of sidefill until the required depth of sidefill is obtained. lt is advisable to leave the crown of the pipe exposed during this compaction.

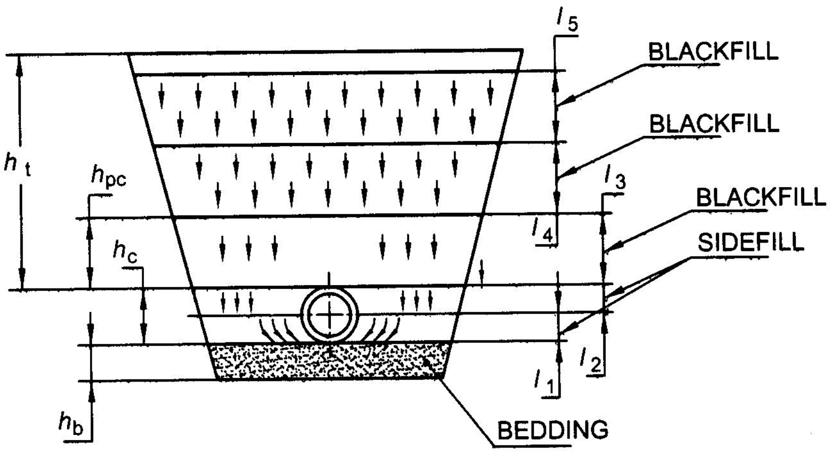


FIG. 11 SIDEFILLING AND BACKFILLING

The third layer (*see* Fig. 10, dimension l_3) should extend to a level 0.3 m above the top of the pipe and should be compacted with light rammers on either side of the pipe only. There should be no ramming of this layer on top of the pipe. On no account should any further material be tipped into the trench before the third layer has been completed. Filling and tamping should then proceed evenly so as to maintain an even pressure on both sides of the pipe.

As indicated by the arrows in Fig. 11, the final layers of dimensions l_4 and l_5 should be compacted over the full width of the trench to the specified procter value for compaction. Allowance should be made for the final layers of backfill for topsoil or road surfacing. Backfilling with frozen backfill is not allowed.

Where there is a high ground water level or other similar wet conditions, backfilling should be carried out quickly to avoid the flotation of pipes.

Where trench supports are used in the construction of the trench, they should be carefully removed as each layer of backfill is laid.

NOTE — The Procter value expresses the relationship between the dry unit weight (density) and the water content of a soil for a given compactive effort.

ANNEX C

(*Clause* 9.1)

DETERMINATION OF RING STIFFNESS

C-1 This annex specifies the method for testing the ring stiffness of a thermoplastics pipe having a circular cross-section.

C-2 SYMBOLS

The following symbols are applicable:

e_c — construction height, in mm
d_n — nominal diameter of pipe, in mm
d_i — internal diameter of pipe test piece, in m
F — loading force, in kN
L — length of test piece, in m
p — pitch of ribs, in mm
S — ring stiffness, in kN/m^2
y — vertical deflection, in m

C-3 PRINCIPLE

The ring stiffness is determined by measuring the force and the deflection while deflecting the pipe at a constant rate.

A length of pipe supported horizontally is compressed vertically between two parallel flat plates moved at a constant speed, which is dependent upon the diameter of the pipe, as given in Table 14.

A plot of force *versus* deflection is generated. The ring stiffness is calculated as a function of the force necessary to produce a deflection of $0.03d_1$ diametrically across the pipe.

Table 14 Deflection Speeds

(*Clause* C-3)

Sl No.	Nominal Diameter of Pipe, d_n mm	Deflection Speed mm/min
(1)	(2)	(3)
i)	$d_n \leq 100$	2 ± 0.1
ii)	$100 < d_n \leq 200$	5 ± 0.25
iii)	$200 < d_n \leq 400$	10 ± 0.5
iv)	$400 < d_n \leq 710$	20 ± 1
v)	$d_n > 710$	$0.03 \times d_1 \pm 5$ percent[1)]

[1)] d_1 shall be determined in accordance with **C-5.3**.

C-4 APPARATUS

C-4.1 Compressive Testing Machine, capable of a constant rate of cross-head movement adjustable as appropriate to the nominal diameter of the pipe in conformance with Table 14, with sufficient force and travel to produce the specified deflection (*see* **C-7**) *via* a pair of parallel plates (*see* **C-4.2**).

C-4.2 A Pair of Hard and Rigid Plates, through which the compressive force can be applied to the test piece. The plates shall be flat, smooth and clean and shall not deform during the test to an extent that would affect the results.

The length of each plate shall be at least equal to the length of the test piece or greater. The width of each plate shall be not less than the maximum width of the surface in contact with the test piece while under load plus 25 mm.

C-4.3 Measuring devices, capable of determining,

a) the length of the test piece to within 1 mm (*see* **C-5.2.2** and **C-5.2.3**);
b) the inside diameter for a test piece to within 0.5 percent; and
c) the change in inside diameter of a test piece in the direction of loading with an accuracy of 0.1 mm or 1 percent of the deflection, whichever is greater.

An example of a device for measuring the inside diameter of corrugation is shown in Fig. 12.

C-4.4 Force Measuring Device, capable of determining to within 2 percent the force necessary to produce up to 4 percent deflection of the test piece.

C-5 TEST PIECES

C-5.1 Marking and Number of Test Pieces

The pipe for which the ring stiffness is to be determined shall be marked on the outside along its full length with a line along one generatrix. Three test pieces *a*, *b* and *c*, respectively, shall be taken from this marked pipe such that the ends of the test pieces are perpendicular to the pipe axis and their lengths conform to **C-5.2**.

C-5.1.1 *Length of Test Pieces*

The length of each test piece shall be determined by calculating the arithmetic mean of three to six length measurements equally spaced around the perimeter of the pipe as given in Table 15. The length of each test piece shall conform to **C-5.1.2** or **C-5.1.3**, as applicable.

Each of the three to six length measurements shall be determined to within 1 mm.

For each individual test piece, the smallest of the three to six measurements shall not be less than 0.9 times the largest length measurement.

C-5.1.2 For pipes that have nominal diameters equal to or less than 1 500 mm, the average length of the test pieces shall be 300 ± 10 mm.

Table 15 Number of Length Measurements

(*Clause* C-5.1.1)

Sl No. (1)	Nominal Diameter of the Pipe, d_n mm (2)	Number of Length Measurements (3)
i)	$d_n < 200$	3
ii)	$200 \le d_n < 500$	4
iii)	$d_n \le 500$	6

C-5.1.3 Structured wall pipes with perpendicular ribs, corrugations or other regular structures, shall be cut such that each test piece contain a whole number of ribs, corrugations or other structures. The cuts shall be made at the midpoint between the ribs, corrugations or other structures.

The length of the test piece shall be the minimum whole number of ribs, corrugations or other structures resulting in a length of 290 mm or greater or for pipes that have nominal diameter greater than 1 500 mm, the average length of the test piece shall be 0.2 d_n or greater (*see* Fig. 13).

C-5.1.4 Structured wall pipes with helical ribs, corrugations or other regular structures shall be cut such that the length of the test pieces is equal to the inside diameter ± 20 mm but not less than 290 mm nor greater than 1 000 mm.

C-5.2 Inside Diameter of Test Piece(s)

Determine the inside diameters d_{ia} and d_{ib} and d_{ic} of the respective test pieces *a*, *b* and *c* (*see* **C-5.1**), as the arithmetic mean of four measurement at 45° intervals of one cross-section at mid-length, each measurement being made to within 0.5 percent or measured at mid length cross section by means of a π tape,

Record the calculated mean inside diameter $d_{ia,}$ d_{ib} and d_{ic} for each test piece *a*, *b* and *c* respectively.

Calculate the average value d_i of these three values using the following equation:

$$d_i = \frac{d_{ia} + d_{ib} + d_{ic}}{3}$$

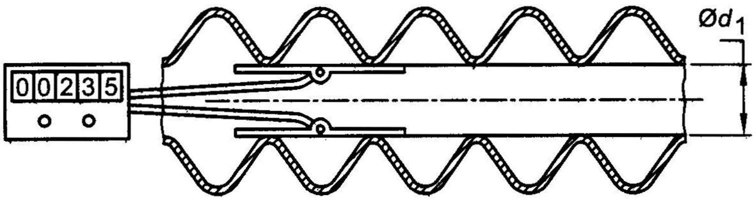


FIG. 12 EXAMPLES OF A DEVICE FOR MEASURING THE INSIDE DIAMETER OF A CORRUGATED PIPE

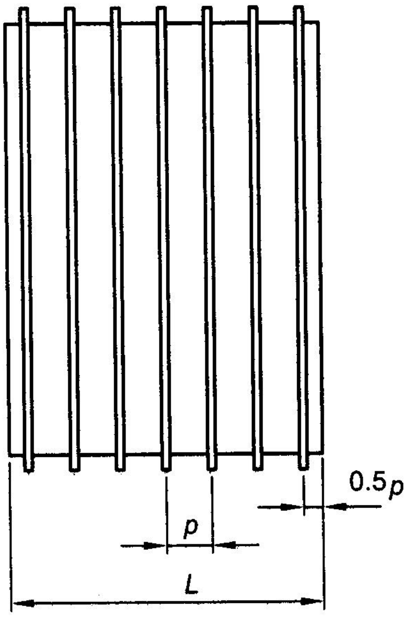


FIG. 13 TEST PIECES CUT OUT OF A PERPENDICULARLY RIBBED PIPE

C-5.3 Age of Test Pieces

At the start of the test the age of the test pieces shall be at least 24 h.

For type testing and in case of dispute, the age of the test pieces shall be 21 ± 2 days.

C-6 CONDITIONING

The test pieces shall be conditioned in air at the test temperature (*see* **C-7.1**) for at least 24 h immediately prior to testing.

C-7 PROCEDURE

C-7.1 Carry out the test procedures at 27 ± 2°C.

C-7.2 If it can be determined in which position the test piece has the lowest ring stiffness, place the first test piece, *a*, in this position in the compressive testing machine. Otherwise place the first test piece in such a way that the marking line is in contact with the upper plate. Rotate the two others, *b* and *c*, 120° and 240°, respectively, in relation to the piece when placing them in the testing machine.

C-7.3 For each test piece, attach the deflection gauge and check the angular position of the test piece, with respect to the upper plate.

Position the test piece with its longitudinal axis parallel to the plates and centre it laterally in the testing machine.

Lower the loading plate until it touches the upper part of the test piece.

Apply one of the following pre-load forces, F_0 as applicable rounded up to the nearest Newton if calculated, from following equation, taking into account as applicable the mass of the loading plate:

For pipes with d_i larger than 100 mm, F_0 shall be calculated using the following equation, in Newton and the result rounded up where necessary to the next higher Newton:

$$F_0 = 250 \times 10^{-6} d_n \times L$$

where

d_n = nominal diameter of the pipe, in mm; and
L = actual length of the test piece, in mm.

The actually applied pre-load force shall be between 95 percent and 105 percent of the calculated force when measured with the accuracy possible with the load cell used for the test.

Then adjust the deflection gauge and load cell to zero. In case of dispute, the zero adjustment method shall be used (*see* **C-7.4**).

Compress the test piece at a constant speed in accordance with Table 14, while continuously recording force and deflection measurements in conformance with **C-7.4**, until reaching at least $0.03d_i$.

NOTES

1 In order to obtain the correct reading from the load cell it is necessary to position the test piece so that the expected resulting force is approximately in line with the axis of the load cell.

2 When determination of ring flexibility is required, the deflection can be continued until the deflection required for ring flexibility has been reached.

3 Pipes with d_n less than or equal to 100 mm, F_0 shall be 7.5 N.

C-7.4 Typically the force and deflection measurements are generated continuously by measuring the displacements of one of the plates but if during the test, the pipe wall height, e_c (*see* Fig. 14) change by more than 5 percent, generate the force/deflection plot by measuring the change in the inside diameter of the test piece.

If the force deflection plot, which is typically a smooth curve, indicates that zero point may be incorrect, as shown in Fig. 15, extrapolate back the initial straight line portion of the curve and use the intersect with the horizontal axis as the (0.0) point (origin).

C-8 CALCULATION OF RING STIFFNESS

Calculate the ring stiffness of each of the three test pieces *a*, *b* and *c*, using the following equations:

$S_a = (0.018\,6 + 0.025\, y_a/d_i)\, F_a/L_a\, y_a$
$S_b = (0.018\,6 + 0.025\, y_b/d_i)\, F_b/L_b\, y_b$

$S_c = (0.018\,6 + 0.025\, y_c/d_i)\, F_c/L_c\, y_c$

where

F_a, F_b, F_c = force corresponding to 3.0 percent pipe deflection in Kn;

L_a, L_b, L_c = length of the test piece, in m; and

y_a, y_b, y_c = deflection, in m, corresponding to 3.0 percent deflection, that is, $\frac{y}{d_i} = 0.03$.

Calculate the ring stiffness of the pipe, in kN/m^2, as the mean of these three values, using the following equation:

$$S = \frac{S_a + S_b + S_c}{3}$$

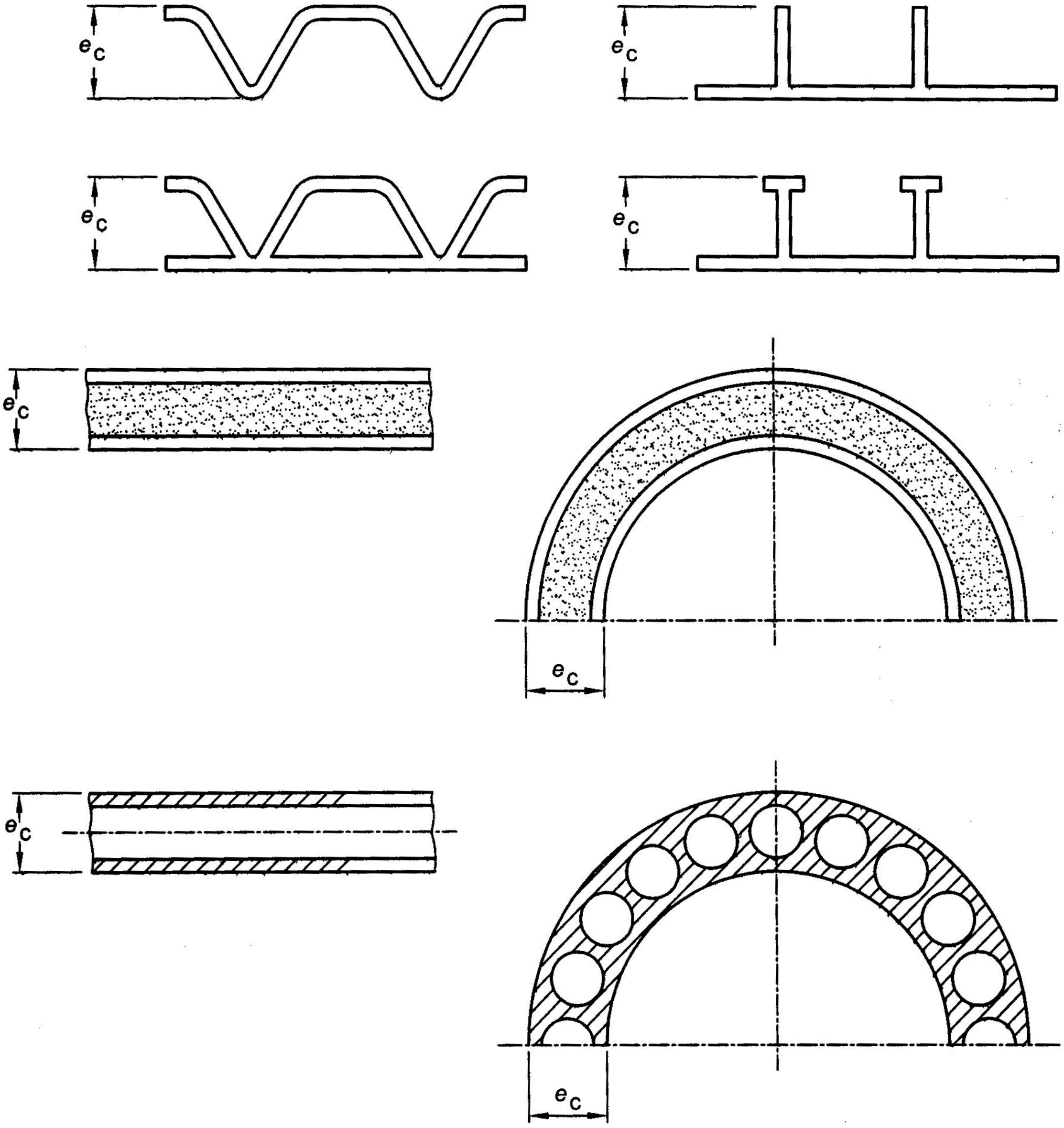


FIG. 14 EXAMPLES OF THE PIPE — WALL HEIGHT, e_c

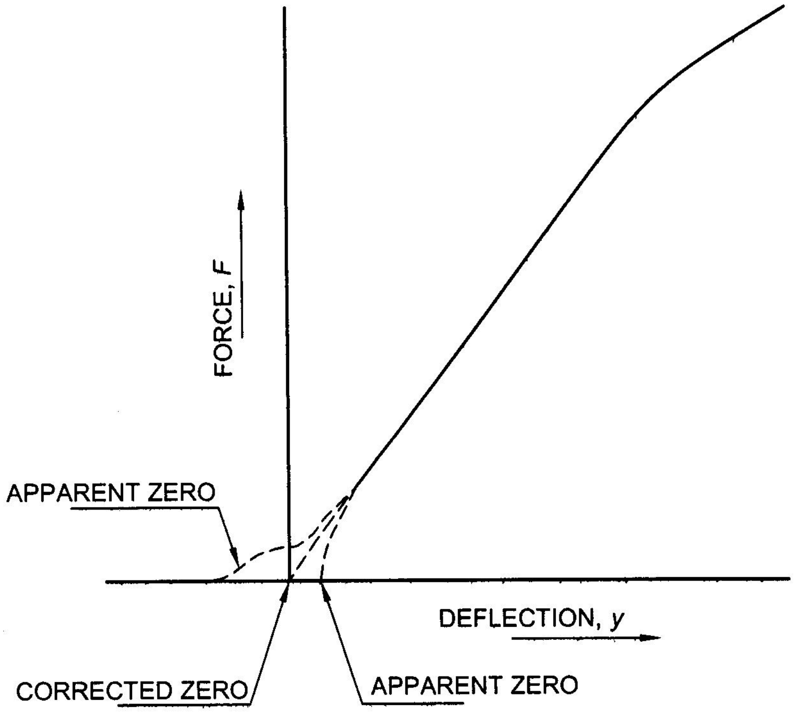


FIG. 15 METHOD OF CORRECTING THE ORIGIN

ANNEX D

(*Clause* 9.3)

DETERMINATION OF RING FLEXIBILITY

D-1 This annex specifies a method for testing the ring flexibility of a thermoplastics pipe having a circular cross-section. The method enables determination of the deflection and necessary force, at which physical damage, if any (*see* **D-6.2**), occurs within 30 percent diametric deflection.

D-2 PRINCIPLE

The ring flexibility of a pipe is tested by measuring the force and the deflection while deflecting a ring section from the pipe diametrically at a constant speed until a deflection of at least 30 percent is achieved or prior fracture has occurred. Each test piece is monitored during testing and subsequently inspected for signs of several specific types of mechanical failure.

D-3 APPARATUS

D-3.1 Compression testing machine capable of producing at least 30 percent diametric deflection of the test piece at the applicable speed.

D-3.2 Dimensional and force measuring devices, capable of measuring diametric deflections up to at least 30 percent and the relevant diameters and compressive forces.

D-4 TEST PIECES

Three test pieces shall be prepared from a single pipe and designated as *a*, *b* and *c*, respectively.

D-5 CONDITIONING

Condition the test pieces in air at the temperature (*see* **D-6.1**) for at least 24 h immediately prior to testing in accordance with **D-6**.

D-6 PROCEDURE

D-6.1 Conduct the test in accordance with the procedure given in Annex A, but continue compression while measuring the change in either inside diameter or outside diameter and monitoring for signs of failure (*see* **D-6.2**), until either a deflection of at least 30 percent in outside diameter has been reached or the test piece has fractured, whichever occurs first.

D-6.2 Observe and record the force evidence of each of the following:

a) Cracking or crazing of the inside wall or liner;
b) Wall cracking;
c) Wall delamination;
d) Rupture of the test piece and the deflection at the first mechanical failures, if they occur; and
e) Change in direction of curvature of the cross-section of the test piece (buckling).

Whitening of the pipe shall not be considered as an indication of one of the above mentioned mechanical failures.

D-6.3 For each test piece, prepare a force *versus* deflection graph and inspect and record the type and the position of each event (*see* **D-6.2**) with respect to the corresponding force and deflection.

ANNEX E

(*Clause* 9.4)

DETERMINATION OF CREEP RATIO

E-1 This annex specifies a method of determining the creep ratio of thermoplastics pipes having a circular cross-section.

E-2 SYMBOLS

The following symbols are used in this annex :

d_n — nominal diameter of pipe, in mm
d_i — inside diameter of pipe test piece, in mm
F — loading force, in kN
F_0 — pre-load force, in N
L — length of test piece, in mm
y_0 — measured initial deflection, in mm
Y_1 — calculated deflection at time t, in mm
Y_2 — extrapolated two-layer deflection, in mm
δ — vertical deflection used to determine the loading force, in mm
y — creep ratio

E-3 PRINCIPLE

A cut length of pipe is placed between two parallel flat horizontal plates and a constant compressive force is applied for 1 008 h (42 days).

The deflection of pipe is recorded at specified intervals so as to prepare a plot of pipe deflection against time. The linearity of the data is analyzed and the creep ratio is calculated as the ratio between two years extrapolated deflection value and the measured 6 min (0.1h) deflection.

NOTE — It is assumed that the test temperature, as appropriate (*see* **E-7.1**), is set.

E-4 APPARATUS

E-4.1 Compressive Loading Machine, capable of applying to the pipe *via* plates (*see* **E-4.2**) and maintaining to within 1 percent both the applicable pre-load force F_0 (*see* **E-7.4**) and the necessary loading force F (*see* **E-7.5**) on the pipe.

E-4.2 Two Steel Plates, through which the compressive force can be applied to the test piece. The plates shall be flat, smooth and clean and shall not deform during the test to an extent that would affect the results.

The length of steel plate shall be at least equal to the length of the test piece. The width of each plate shall be not less than the maximum width of the surface in contact with the test piece while under load plus 25 mm.

E-4.3 Dimensional Measuring Device, capable of determining the length of the test piece to within 1 mm (*see* **E-5.2**), the inside diameter of the test piece to within 0.1mm or 0.2 percent of d_n, whichever is greater and the change in inside diameter of the test piece in the direction of loading with an accuracy of 0.1mm, or 1 percent of the deflection, whichever is the greater.

E-4.4 Timer, capable of determining the first 6 min with an accuracy to within 1 s and the remaining times to within 0.1 percent (*see* **E-7.5** and **E-7.6**).

E-5 TEST PIECE

E-5.1 Marking and Number of Test Pieces

The pipe for which the creep ratio is to be determined shall be marked on the outside along its full length with a line along one generatrix. Three test pieces *a*, *b* and *c*, respectively, shall be taken from this marked pipe such that the ends of the test pieces are perpendicular to the pipe axis and their lengths conform **E-5.2**.

E-5.2 Length of Test Pieces

E-5.2.1 The length of each test piece shall be determined by calculating the arithmetic mean of three

Table 16 Number of Length Measurements

(*Clause* E-5.2.1)

Sl No.	Nominal diameter of the Pipe, d_n mm	Number of Length Measurements
(1)	(2)	(3)
i)	$d_n < 200$	3
ii)	$200 \le d_n < 500$	4
iii)	$d_n \ge 500$	6

to six length measurements equally spaced around the perimeter of the pipes given in Table 16. The length of each test pieces shall conform to **E-5.2.2** and **E-5.2.3** as applicable.

Each of the three to six length measurements shall be made to within 1 mm.

For each individual test piece, the smallest of the three to six length measurements shall not be less than 0.9 times the largest measurement.

E-5.2.2 For pipes that have nominal diameters less than or equal to 1 500 mm, the average length of each test piece shall be 300 ± 10 mm.

E-5.2.3 For pipes that have nominal diameter greater than 1 500 mm, the average length, in millimetres, of each test piece shall be at least 0.2 d_n.

E-5.3 Inside Diameter of Test Piece

The inside diameters, d_{ia}, d_{ib} and d_{ic} of the respective test piece *a*, *b* and *c* (*see* **E-5.1**) shall be determined either,

a) as the arithmetic average of four measurements obtained at 45° intervals on one cross-section at mid-length, where each measurement shall be determined to within 0.1 mm or 0.2 percent of d_i, whichever is greater; or

b) measured at mid-length of cross-section by means of a pie tape.

Record the calculated mean inside diameter d_{ia}, d_{ib} and d_{ic} for each test piece *a*, *b* and *c* respectively.

Calculate the average value d_i of these three values using the following equation:

$$d_i = \frac{d_{ia} + d_{ib} + d_{ic}}{3}$$

E-5.4 Age of Test Pieces

At the start of the test, the age of the test pieces shall be 21 ± 2 days.

E-6 CONDITION

Condition the test pieces in air at the temperature (*see* **E-7.1**) for at least 24h immediately prior to testing in accordance with **E-7**.

E-7 PROCEDURE

E-7.1 Carry out the test at 27 ± 2°C.

E-7.2 If it can be determined in which position the test piece has the lowest ring stiffness, place the first test piece, *a* in this position in the compressive testing machine.

Otherwise, place the first test piece in such a way that the marking line is in contact with the upper plate. Rotate the two others, *b* and *c*, by 120° and 240° respectively, in rotation to the first test piece when placing them in the testing machine.

E-7.3 For each test piece, attach the deflection gauge and check the angular position of the test piece with respect to the upper plate.

E-7.4 Lower the upper plate until it touches the upper part of the test piece.

Apply one of the following pre-load forces F_0, as applicable, taking into account the mass of the upper plate:

a) for pipes with d_i less than or equal to 0.1 m, F_0 shall be 7.5N;

b) for pipes with d_i larger than 0.1 m, F_0 shall be calculated using following equation and rounding the result, where necessary to the next higher integer

$$F_0 = 0.000\,25\, d_n .\, L$$

where

F_0 = calculated pre-load, in N;

d_n = nominal outside diameter of the pipe, in mm; and

L = calculated average length of the test piece, in mm.

The applied pre-load force shall be between 95 percent and 105 percent of the calculated force.

E-7.5 Within 5 min of applying the pre-load force, set the deflection gauge to zero and start applying a steadily increasing compressive force such that, between 20 s and 30 s after starting, a loading force *F* is reached. This force *F* shall be chosen such that after 360 s (6 min) the test piece shows a deflection ratio of 1.5 ± 0.2 percent, that is,

$$\frac{\delta}{d_i} = 0.15 \pm 0.002$$

At the moment when this full loading force *F* is reached apply measure the reading and then calculate the creep ratio as given in **E-8**.

E-8 EXAMPLE OF A CREEP CALCULATION

A typical set of deflection/time data for one test piece is given in Table 17 together with the subsequently calculated values of M, B, R and Y_2 for different ranges of points as given in column, which indicates points which have been included in the regression analysis.

The resulting plot is given in Fig. 16 where, in accordance with **E-8**, Y_2 is based on the set of not less than five points for which R has the highest values above 0.990.

E-9 CONTINUATION OF TEST

If the use of even the last five points does not lead to a correction coefficient higher than 0.990 in the regression analysis for any of the test pieces, continue the test on all three test pieces by measuring the deflection at 1 200 h, 1 400 h, 1 660 h, 2 000 h, 2 400 h, 2 818 h, 3 400 h and 4 000 h, in each case ±24 h, or until the correlation factor exceed 0.990, using the last five measurements, whichever occurs first.

Table 17 Typical Set of Deflection/Time Data for One Test Piece
(*Clause* E-8)

Sl No. (1)	Point Number (2)	Time, t h (3)	Y_t mm (4)	Range of Points (5)	M (6)	B (7)	R (8)	Y_2 mm (9)
i)	1	0.1	6.629	1-11	0.505	6.683	0.950	8.830
ii)	2	1	6.648	2-11	0.612	6.424	0.967	8.023
iii)	3	4	6.780	3-11	0.710	6.170	0.972	9.185
iv)	4	24	7.019	4-11	0.888	6.695	0.982	9.463
v)	5	168	7.534	5-11	1.196	4.842	0.996	9.921
vi)	6	338	7.849	6-11	1.311	4.617	0.996	10.081
vii)	7	504	8.049	7-11	1.422	4.195	0.998	10.232
viii)	8	600	8.134	—	—	—	—	—
ix)	9	698	8.234	—	—	—	—	—
x)	10	884	8.384	—	—	—	—	—
xi)	11	1 008	8.464	—	—	—	—	—

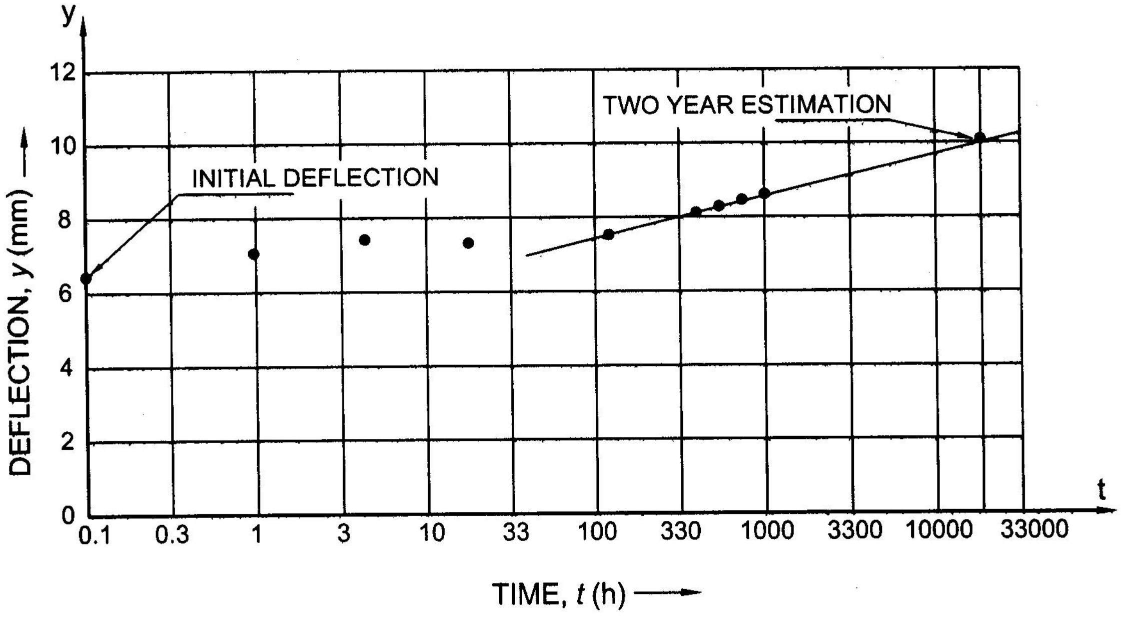


FIG. 16 DEFLECTION/TIME PLOT FOR ONE TEST PIECE

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: CED 50 (7794).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices:		*Telephones*
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	2337 8499, 2337 8561 2337 8626, 2337 9120
Northern	: SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 3843 60 9285
Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	2254 1216, 2254 1442 2254 2519, 2254 2315
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.

Published by BIS, New Delhi